CLAIMS

What is claimed is:

1. A method of controlling a multivariable system comprising:

monitoring a plurality of control variables of interest in the system;

selecting one of the control variables for regulation control and regulating the selected control variable relative to a desired setpoint while continuing to monitor the remaining ones of the control variables; and

selectively switching regulation control over to one of the remaining ones of the control variables and regulating that control variable relative to a desired setpoint if that control variable is detected as exceeding an allowed value.

2. The method of claim 1, further comprising storing one or more parameter values for each of the control variables, and configuring a control circuit to use the stored parameter values corresponding to a particular one of the control variables where that particular control variable is selected for regulation control.

3. The method of claim 2, wherein the control circuit comprises a PID controller, and wherein the stored parameter values for each control variable comprise at least one of a proportional gain term, an integral gain term, and a derivative gain term.

4. The method of claim 3, further comprising providing an individual control loop for each control variable, and closing the control loop corresponding to the selected control variable through the PID controller.

5. The method of claim 1, further comprising defining an order of control precedence that determines the particular control variable selected for regulation control if two or more of the control variables are detected as exceeding their allowed values.

6. The method of claim 1, further comprising designating a particular one of the control variables as a default regulation variable, and assigning a lowest control precedence to the default regulation variable.

7. The method of claim 1, wherein the multivariable system comprises an alternative energy system configured to operate from an electrical energy storage device (EESD) and an alternative energy generation device (AEGD), the method further comprising coupling an EESD input of the system to a dc bus through a first power flow control device that controls power flow between the EESD and the dc bus, and coupling an AEGD input to the dc bus through a reverse blocking circuit configured to prevent current flow from the dc bus into the AEGD.

8. The method of claim 7, wherein selecting one of the control variables for regulation control and regulating the selected control variable relative to a desired setpoint while continuing to monitor the remaining ones of the control variables comprises regulating the selected control variable by controlling the power flow between the EESD and the dc bus responsive to measuring an error between the selected control variable and the desired setpoint for the selected control variable.

9. The method of claim 8, wherein selectively switching regulation control over to one of the remaining ones of the control variables and regulating that control variable relative to a desired setpoint if that control variable is detected as exceeding an allowed value comprises selecting one of the remaining control variables as a new regulation control variable and controlling the power

flow between the EESD and the dc bus responsive to an error between a measured value of the new regulation control variable and a corresponding desired setpoint.

10. The method of claim 8, wherein the first power flow device comprises a bi-directional converter that controls bi-directional converter current flow responsive to a duty cycle of an applied switching signal, and wherein controlling the power flow comprises controlling the duty cycle of the switching signal.

11. The method of claim 7, wherein the alternative energy system further comprises an ac inverter that is selectively coupled to an ac electrical system in a grid-parallel mode of operation of the alternative energy system.

12. The method of claim 11, further comprising selectively regulating AEGD current and dc bus voltage by operating the ac inverter as a second power flow device to control power flow between the dc bus and the ac electrical system.

13. The method of claim 12, further comprising, when operating in the grid-parallel mode, selectively regulating EESD voltage and EESD current via the first power flow device, and selectively regulating AEGD current and dc bus voltage via the second power flow device.

14. The method of claim 7, wherein the plurality of control variables comprises an EESD current, an EESD voltage, a dc bus voltage, and an AEGD current, and further comprising defining an order of control precedence for the control variables and selecting the control variables for regulation according to the order of control precedence.

15. The method of claim 14, wherein, in a charging mode of the alternative energy system, defining the order of control precedence as the dc bus voltage, the AEGD current, and either the EESD voltage or EESD current as a function of their values with respect to their maximum settings.

16. The method of claim 14, wherein, in a non-charging mode of the alternative energy system, defining the order of control precedence as the dc bus voltage, and the AEGD current.

17. The method of claim 14, further comprising selecting one of the control variables as a default variable, and setting the default variable to a lowest priority in the order of control precedence.

18. A multivariable control apparatus to control a multivariable system, the apparatus comprising:

one or more monitoring circuits configured to generate error signals relative to desired setpoints for a corresponding plurality of control variables of interest in the system; and

a control circuit configured to select one of the control variables for regulation control and regulate the selected control variable based on the corresponding error signal, and further configured selectively to switch regulation control over to any of the remaining ones of the control variables responsive to detecting that any one of the remaining control variables is exceeding an allowed value.

19. The apparatus of claim 18, further comprising one or more storage devices operative associated with the control circuit to store one or more parameter values for each of the control variables, and wherein the control circuit is configured to use the stored parameter values corresponding to a particular one of the control variables where that particular control variable is selected for regulation control.

20. The apparatus of claim 19, wherein the control circuit comprises a PID controller, and wherein the stored parameter values for each control variable comprise at least one of a proportional gain term, an integral gain term, and a derivative gain term.

21. The apparatus of claim 20, wherein the PID controller is configured to provide an individual control loop for each control variable, and to close the control loop corresponding to the selected control variable through the PID controller.

22. The apparatus of claim 18, wherein the control circuit is configured to select control variables according to a defined order of control precedence that determines the particular control variable selected for regulation control if two or more of the control variables are detected as exceeding their allowed values.

23. The apparatus of claim 18, wherein the apparatus comprises at least a portion of an alternative energy control system, the apparatus further comprising a first power flow device to couple an electrical energy storage device (EESD) to a dc bus within the alternative energy control system, and a reverse blocking circuit to couple an alternative energy generation device (AEGD) to the dc bus, and wherein the first power flow device is configured to control power flow between the EESD and the DC bus, and the reverse blocking circuit is configured to prevent current from flowing into the AEGD from the dc bus.

24. The apparatus of claim 23, wherein the apparatus the apparatus regulates the selected control variable by controlling the power flow between the EESD and the dc bus responsive to the corresponding error signal.

25. The apparatus of claim 24, wherein the first power flow device comprises a bi-directional converter that controls bi-directional converter current flow responsive to a duty cycle of an applied switching signal, and wherein the apparatus controls the power flow between the EESD and the dc bus by controlling the duty cycle of the switching signal.

26. The apparatus of claim 23, wherein the apparatus further comprises an ac inverter that is selectively coupled to an ac electrical system in a grid-parallel mode of operation of the alternative energy system.

27. The apparatus of claim 26, wherein the apparatus is configured to selectively regulate AEGD current and dc bus voltage by operating the ac inverter as a second power flow device to control power flow between the dc bus and the ac electrical system.

28. The apparatus of claim 27, wherein the apparatus is configured to selectively regulate EESD voltage and EESD current via the first power flow device, and selectively regulate AEGD current and dc bus voltage via the second power flow device, when operating in the grid-parallel mode.

29. A multivariable control apparatus for controlling an alternative energy system, the apparatus comprising:

a first power flow device to control power flow between an electrical energy storage device (EESD) associated with the system and a dc bus included within the system;

a reverse blocking circuit to couple an alternative energy generation device (AEGD) to the dc bus and prevent reverse current flow from the dc bus into the AEGD;

an ac inverter to generate ac power from dc power supplied by the dc bus; and

a multivariable control circuit to monitor a set of control variables comprising two or more of an EESD voltage, an EESD current, an AEGD current, and a dc bus voltage;

said multivariable control circuit configured to control the first power flow device in one or more operating modes of the alternative energy system to regulate a selected one of the control variables relative to a corresponding desired setpoint, and to change which control variable is selected for regulation control responsive to detecting that a non-selected control variable is exceeding an allowed value.

30. The apparatus of claim 29, wherein the ac inverter operates as a second power flow device by controlling power flow between the dc bus and an external ac electrical system, and wherein, in a grid-parallel operating mode in which the ac inverter is coupled to the external electrical system, the multivariable control circuit is configured to regulate a selected one of the AEGD current and the dc bus voltage by controlling the second power flow device and simultaneously to regulate a selected one of the EESD voltage and EESD current by controlling the first power flow device.

31. The apparatus of claim 30, wherein the multivariable control circuit comprises a dc control circuit configured to control the first power flow device, and an ac control circuit configured to control the second power flow device.

32. The apparatus of claim 31, wherein the dc control circuit is configured to regulate a selected one of the EESD voltage, the EESD current, the AEGD current, and the dc bus voltage if not in the grid-parallel mode.

33. The apparatus of claim 29, wherein the first power flow device comprises a bi-directional converter that controls current flow between the EESD and the dc bus responsive to a duty cycle of an applied switching signal, and wherein the multivariable control circuit is configured to regulate the selected control variable by controlling the duty cycle of the switching signal.

34. The apparatus of claim 29, wherein the apparatus operates in one or more modes, and wherein the multivariable control circuit is configured to select control variables for regulation control according to a mode-dependent order of precedence.

35. The apparatus of claim 29, wherein the one or more modes include an EESD charging mode, and wherein the multivariable control circuit is configured to monitor the EESD voltage and the EESD current relative to maximum allowed values, and to select one of them for regulation control based on that monitoring.

36. The apparatus of claim 35, wherein the multivariable control circuit is configured to select the EESD current for regulation control in the charging mode if neither the EESD voltage nor the EESD current exceed their respective maximum allowed values.

37. The apparatus of claim 29, wherein the multivariable control circuit is configured to operate in an idle mode where it adjusts the setpoint corresponding to the dc bus voltage to a minimum value such that the dc bus voltage is less likely to be selected for regulation control by making it

less likely that the dc bus voltage will fall outside an allowed range.

38. The apparatus of claim 37, wherein the multivariable control circuit is further configured to adjust the setpoint corresponding to the AEGD current such that it permits the AEGD current to rise to a maximum allowed value before attempting to regulate the AEGD current downward.

39. The apparatus of claim 38, wherein the multivariable control circuit is configured to adjust the setpoints corresponding to the dc bus voltage and the AEGD current based on receiving command values from a supervisory control circuit.

40. The apparatus of claim 29, wherein the multivariable control circuit comprises:

a control loop input circuit for each control variable in the set of control variables;

a mode select circuit to select a regulation mode based on receiving one or more detection signals from each of the control loop input circuits; and

a PID regulator circuit configured to generate a control signal for the first power flow device based on an error between the selected control variable and its corresponding desired setpoint.

41. The apparatus of claim 40, wherein the PID regulator circuit is configured to adjust one or more of a derivative gain term, a proportional gain term, and an integral gain term based on the selected control variable.

42. The apparatus of claim 41, wherein the PID regulator circuit is configured to tune its operations for regulating each of the control variables in the set of control variables by setting one or more of the gain terms based on one or more parameters stored for each control variable.

43. The apparatus of claim 40, further comprising a second PID regulator circuit configured to control the ac inverter as a second power flow device, and wherein, when the apparatus is operating in a grid-parallel mode, the multivariable control circuit is configured to regulate a selected one of the EESD current and the EESD voltage by controlling the first power flow device via the first PID regulator circuit, and is configured to regulate a selected one of the AEGD current and the dc bus voltage by controlling the second PID regulator circuit via the second PID regulator circuit.

44. The apparatus of claim 29, wherein the first power flow device comprises a bi-directional converter controller configured to control a bi-directional converter current flowing between the EESD and the dc bus responsive to a duty cycle of the control signal.

45. A computer readable medium storing a computer program for controlling a multivariable system, the computer program comprising:

program instructions to monitor a plurality of control variables of interest in the system;

program instructions to select one of the control variables for regulation control and regulate the selected control variable relative to a desired setpoint while continuing to monitor the remaining ones of the control variables; and

program instructions to selectively switch regulation control over to one of the remaining ones of the control variables and regulate that control variable relative to a desired setpoint if that control variable is detected as exceeding an allowed value.

46. The computer readable medium storing the computer program of claim 45, wherein the multivariable system comprises an alternative energy system that includes an ac inverter coupled to an external electrical system and configured to generate ac power from dc power supplied by a dc bus within the alternative energy system, and wherein the alternative energy system further comprises a first power flow device to couple an electrical energy storage device (EESD) to the dc bus and to control power flow between the EESD and the dc bus, and a reverse blocking circuit to couple an alternative energy generation device (AEGD) to the dc bus and to prevent reverse current from flowing into the AEGD from the dc bus, and wherein the program instructions to monitor a plurality of control variables comprise program instructions to monitor two or more of an EESD current, an EESD voltage, an AEGD current, and a dc bus voltage.

47. The computer readable medium storing the computer program of claim 46, wherein the computer program further comprises program instructions to select which ones in the set of control variables are subject to regulation control, and to set an order of selection preference for them based on an operating mode of the alternative energy system.

48. The computer readable medium storing the computer program of claim 46, wherein the program instructions to regulate the selected control variable relative to a desired setpoint while continuing to monitor the remaining ones of the control variables comprise program instructions to effect regulation control of the selected control variable by controlling the power flow between the EESD and the dc bus via the first power flow device.

49. The computer readable medium storing the computer program of claim 48, further comprising program instructions to regulate a selected one of the EESD current and the EESD voltage by controlling the first power flow device, and program instructions simultaneously to operate the ac inverter as a second power flow device to thereby control power flow between the dc bus and the external electrical system, and to regulate a selected one of the AEGD current and the dc bus voltage via the second power flow device.